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Dry-matter accumulation at pre- and post-anthesis and yield of wheat (*Triticum aestivum*) as affected by temperature stress and genotypes

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ABSTRACT

A field experiment was carried out during 2000–2001 and 2001–2002 to study the effect of sowing time and genotypes on biomass accumulation and yield in wheat (*Triticum aestivum* L. emend. Fiori & Paol.) at Pantnagar, Uttaranchal. Normal sown crop (22 November) accumulated significantly higher dry matter in different plant parts and yielded higher than late-sown crop (22 December). Leaf dry weight increased up to 10 days after anthesis and declined thereafter, whereas stem, spike and total dry weight increased up to maturity without showing any decreasing pattern. The highest spike dry weight at all the stages was recorded in 'UP 2425', whereas 'WH 542' had minimum spike dry weight. At maturity, the highest total dry weight was recorded in 'PBW 343' during both the years. Variety 'PBW 343' performed better and 'WH 542' yielded lower than other varieties under normal sown condition, while 'UP 2425' followed by 'UP 2338' was highest grain-producing variety in December-sown crop.

Key words : Temperature stress, Sowing time, Genotypes, Dry-matter accumulation, Different plant parts, Grain and Biological yield

In north India, rice–wheat cropping system is very popular compared to the other cropping systems. In wheat production, there are several constraints which limit its productivity. Out of them, one of the major constraints being its late planting which ultimately results in exposure of plants to high temperature at grain-development stage.

The effective development of plant parts and dry-matter production are pre-requisite for better expression of inherent potential and better utilization of environment and soil resources to develop and to produce the economic sink by a variety. To explain the yield variation due to different treatments, it is essential to know about the size of assimilatory surface and distribution of assimilates. A plant with larger proportion of leaves with better partitioning ability and high remobilization of accumulated assimilates to growing grain during post-anthesis period may lead to high grain yield in wheat. In view of above consideration, the present investigation was undertaken to understand the effect of genotypic variation under various weather parameters on performance of wheat genotypes under different sowing conditions.

MATERIALS AND METHODS

The experiment was carried out during 2000–2001 and 2001–2002 with 2 dates of sowing, viz. 22 November and 22 December and 12 wheat genotypes, viz. 'CPAN 3004', 'NIAW 34', 'PBW 343', 'PBW 373' 'Raj 3077', 'Raj 3765', 'UP 2003', 'UP 2338', 'UP 2382', 'UP 2425', 'WH 542' and 'WH 896', at Pantnagar. The site is located at 29^0 N, 79.3^o E and at 43.3 m above the mean sea level in the *tarai* belt of Uttaranchal and falls in the subhumid and subtropical climatic zone. The soil was sandy loam in texture, slightly alkaline in reaction, rich in organic carbon, low in available nitrogen, medium in available phosphorus and potassium. The experiment was laid out in spilt-plot design keeping sowing dates in main plots and genotypes in subplot with 3 replications. During 35 days after sowing to physiological maturity, biomass accumulation of above ground parts was recorded at different stages from the sampled plants of 25 cm row length from each plot and converted into g/shoot.

RESULTS AND DISCUSSION

Dry-matter accumulation

The differences in leaf dry weight due to sowing time and varieties were significant during both the years at all the stages except at 35 days after sowing where sowing time had no effect. Delayed sowing resulted in significant reduction in leaf dry weight (Table 1). Low temperature experienced by late-sown crop during early growth or im-

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mediately after seedling emergence might have resulted in poor leaf development. Among the varieties, 'UP 2425' being at par with 'UP 2338', 'NIAW 34,' 'Raj 3765', PBW 343', 'UP 2382' and 'Raj 3077' produced significantly higher leaf dry weight than other varieties during 2000–2001, whereas 'UP 2382' being at par with 'UP 2338' recorded significantly higher leaf dry weight during 2001–2002. However, lowest leaf dry weight was produced by 'WH 542' at 35 days during both the years. At 65 days, the highest leaf dry weight was produced by 'UP 2425' which was at par with 'PBW 343' and 'UP 2338' during both the years. At anthesis, significantly higher leaf dry weight was recorded with 'PBW 343', and 'UP 2338' than other varieties during 2000–2001 and 2001–2002, respectively, but 'PBW 343' was at par with 'NIAW 34' and 'WH 896'. At 10 days after anthesis, 'UP 2338' and 'WH 542' jointly produced highest leaf dry weight during 2000–2001, while 'WH 896' being at par with 'WH 542' produced significantly higher leaf dry weight than the other varieties during 2001–2002. Variety 'PBW 373' produced lowest leaf dry weight during both the years. Leaf dry weight increased up to 10 days after anthesis before showing decreasing pattern. The results confirm the findings of Asana (1966) and Sanwal (1993).

Partitiioning of dry matter towards the stem showed increasing pattern up to the maturity. Significantly higher stem dry weight was recorded under normal-sown crop (normal temperature) in both the years at all the stages except 35 days in both the years and at 10 days after anthesis in 2000–2001 (Table 2). At the time of physiological maturity, significantly higher stem dry weight was recorded with 'PBW 343' than other varieties during both the years, but it was at par with 'UP 2425'. 'WH 896', 'UP 2382', 'Raj 3765' and 'NIAW 34' during 2000–2001, and with 'PBW 373', 'UP 2382', 'NIAW 34' 'CPAN 3004', 'Raj 3765' and 'WH 896' during 2001–2002. The lowest stem dry weight was recorded with 'Raj 3077' and 'UP 2003' during 2000–2001 and 2001–2002 respectively. Singh (1988) also reported reduction in leaf and stem dry weight due to high temperature (under late sowing).

The differences in spike dry weight due to sowing time and varieties was significant at all the stages during both the years. The crop sown on 22 November produced significantly heavier spikes than 22 December sown crop at all the stages (Table 3). At the time of anthesis 'UP 2425', followed by 'UP 2003', 'PBW 373' and 'UP 2338' produced heaviest spike during 2000–2001, whereas 'UP 2338' exhibited the highest spike dry weight during 2001–2002. The lowest spike dry weight at anthesis was produced by 'Raj 3077' and 'WH 542' in 2000–2001 and 2001–2002, respectively. At 10 days after anthesis variety, 'UP 2425' during 2000–2001 and 'PBW 343' and 'UP 2425' during 2001–2002 jointly exhibited highest spike dry weight, whereas the lowest spike dry weight was ob-

Table 1. Effect of sowing dates and varieties on leaf dry weight (g)/shoot at different stages of wheat during 2000–2001 and 2001–2002

Treatment	Leaf dry weight (g/shoot) at different stages of wheat									
	35 DAS		65 DAS		Anthesis		10 DAA		Physiological maturity	
	2000–2001	2001–2002	2000–2001	2001–2002	2000–2001	2001–2002	2000–2001	2001–2002	2000–2001	2001–2002
Sowing date										
22 November	0.090	0.047	0.48	0.28	0.51	0.48	0.50	0.49	0.43	0.40
22 December	0.074	0.047	0.32	0.18	0.38	0.36	0.45	0.42	0.38	0.30
CD (P=0.05)	NS	NS	0.08	0.01	0.002	0.002	0.003	0.002	0.006	0.003
Variety										
'CPAN 3004'	0.066	0.048	0.37	0.24	0.43	0.47	0.53	0.38	0.47	0.40
'NIAW 34'	0.082	0.043	0.43	0.20	0.51	0.46	0.40	0.33	0.36	0.29
'PBW 343'	0.078	0.052	0.44	0.31	0.53	0.46	0.42	0.42	0.49	0.39
'PBW 373'	0.064	0.039	0.34	0.12	0.36	0.40	0.40	0.35	0.30	0.24
'Raj 3077'	0.076	0.040	0.41	0.22	0.40	0.34	0.44	0.42	0.39	0.28
'Raj 3765'	0.079	0.059	0.44	0.29	0.39	0.38	0.37	0.54	0.31	0.41
'UP 2003'	0.054	0.040	0.34	0.25	0.48	0.32	0.50	0.50	0.49	0.31
'UP 2338	0.085	0.069	0.49	0.31	0.42	0.60	0.56	0.42	0.49	0.40
'UP 2382'	0.077	0.071	0.37	0.24	0.48	0.40	0.52	0.53	0.31	0.26
'UP 2425'	0.086	0.061	0.49	0.32	0.43	0.39	0.46	0.51	0.48	0.30
'WH 542'	0.053	0.028	0.36	0.12	0.45	0.37	0.56	0.54	0.33	0.43
'WH 896'	0.064	0.032	0.33	0.16	0.51	0.41	0.55	0.55	0.36	0,46
CD (P=0.05)	0.015	0.004	0.06	0.02	0.040	0.040	0.03	0.03	0.031	0.032

DAS, Days after sowing; DAA, days after anthesis

Table 2. Effect of sowing dates and varieties on stem dry weight (g)/shoot at different stages of wheat during 2000–2001 and 2001–2002

Treatment	Stem dry weight (g/shoot) at different stages of wheat									
	35 DAS		65 DAS		Anthesis		10 DAA		Physiological maturity	
	2000–2001	2001–2002	2000–2001	2001–2002	2000–2001	2001–2002	2000–2001	2001–2002	2000–2001	2001–2002
Sowing date										
22 November	0.036	0.032	1.01	0.57	1.76	1.27	1.75	1.66	2.83	2.54
22 December	0.021	0.030	0.59	0.33	1.40	1.08	1.53	1.15	1.52	1.20
CD(P=0.05)	NS	NS	0.13	0.02	0.301	0.102	NS	0.065	1.003	0.900
Variety										
'CPAN 3004'	0.028	0.025	0.81	0.44	1.28	1.10	1.61	1.49	2.19	1.92
'NIAW 34'	0.027	0.033	0.65	0.26	1.42	1.15	1.63	1.18	2.23	1.96
'PBW 343'	0.040	0.048	0.93	0.70	1.79	1.48	1.97	1.79	2.77	2.46
'PBW 373'	0.028	0.030	0.64	0.15	1.54	1.21	1.76	1.03	2.20	2.02
'Raj 3077'	0.027	0.034	0.90	0.43	1.82	1.03	1.51	1.21	1.76	1.69
'Raj 3765'	0.030	0.039	0.92	0.60	1.85	1.16	1.88	1.62	2.28	1.96
'UP 2003'	0.021	0.019	0.69	0.44	1.23	1.14	1.10	1.33	2.02	1.49
'UP 2338	0.033	0.035	1.03	0.72	1.85	1.35	1.96	1.64	1.85	1.84
'UP 2382'	0.031	0.032	0.72	0.51	1.70	1.17	1.69	1.46	2.29	2.01
'UP 2425'	0.042	0.050	1.02	0.70	1.90	1.35	1.64	1.67	2.61	1.50
'WH 542'	0.016	0.018	0.60	0.17	1.17	0.93	1.30	1.02	1.96	1.71
'WH 896'	0.021	0.037	0.65	0.27	1.33	1.06	1.60	1.45	2.29	1.94
CD (P=0.05)	0.010	0.004	0.20	0.04	0.301	0.095	0.378	0.199	0.556	0.573

DAS, Days after sowing; DAA, days after anthesis

Table 3. Effect of sowing dates and varieties on spike dry weight (g)/shoot at different stages of wheat during 2000–2001 and 2001–2002

Treatment	Spike dry weight (g)/shoot					
	Anthesis		10 days after anthesis		Physiological maturity	
	2000–2001	2001–2002	2000–2001	2001–2002	2000–2001	2001–2002
Sowing date						
22 November	0.52	0.52	1.26	1.25	2.44	2.24
22 December	0.34	0.33	0.95	0.92	2.02	1.92
CD(P=0.05)	0.012	0.018	0.055	0.086	0.057	0.021
Variety						
'CPAN 3004'	0.50	0.47	1.04	0.85	2.19	2.04
'NIAW 34'	0.46	0.37	1.09	1.12	2.29	2.05
'PBW 343'	0.53	0.54	1.45	1.54	2.60	2.45
'PBW 373'	0.45	0.41	0.91	0.86	2.00	1.85
'Raj 3077'	0.28	0.34	1.00	1.15	2.17	1.86
'Raj 3765'	0.34	0.47	1.17	1.04	2.27	2.17
'UP 2003'	0.55	0.27	1.05	1.05	2.01	2.10
'UP 2338'	0.52	0.65	1.29	1.20	2.54	2.29
'UP 2382'	0.37	0.44	1.11	1.12	2.25	2.07
'UP 2425'	0.57	0.61	1.54	1.54	2.67	2.79
'WH 542'	0.37	0.25	0.77	0.73	1.87	1.73
'WH 896'	0.37	0.36	0.85	0.85	2.00	1.85
CD (P=0.05)	0.052	0.052	0.073	0.085	0.083	0.072

served in 'WH 542'. Highest spike dry weight at maturity was recorded in 'UP 2425', followed by 'PBW 343'. Both these varieties had significantly heavier spikes than the other varieties and the lowest was observed in 'WH 542' at maturity during both the years. The late-sown crop was exposed to high temperature during the period of grain filling and therefore, forced to mature early and attained the lower spike dry weight than timely sown crop. The rate of

dry-matter accumulation increased with the increase in crop age which was also reported by Rao (1986).

Reduction in total shoot dry weight with delay in sowing was also observed. At maturity, the highest total dry weight was recorded with 'PBW 343' during both the years, which might be due to their high stem dry weight, spike dry weight and relatively high leaf dry weight (Table 4).

Grain and biological yield

Higher mean grain yield was recorded in 22 November sowing and delay beyond this date resulted in reduction in grain yield (Table 5). Ahuja *et al.* (1996), reported higher grain yield from the crop sown in November than December. However, Sanwal (1998) reported mid-November as optimum time for wheat sowing in foot-hills (*tarai*) belt of Uttar Pradesh. In present investigation, high grain yield of November sown crop may be due to high amount of assimilates produced by more leaves (dry weight) resulting in the production of more number of shoots with larger sink (spikes). Varieties 'PBW 343', 'UP 2338', 'UP 2425', 'Raj 3765' and 'UP 2382' performed better and 'WH 542' yielded lower than other varieties under normal sowing during both the years.

Higher grain yield of 'PBW 343' might be due to better partitioning of dry matter, and grain weight/spike, whereas in December-sown crop, the highest grain producing variety was 'UP 2425', followed by 'UP 2338' and lowest yielder was 'WH 542', followed by 'WH 896'. High grain yield of 'UP 2425' and 'UP 2338' can be attributed to their higher spike dry weight/shoot. There was significantly lower biological yield in December sowing than November sowing during both the years. The late-sown crop was forced to mature early without fulfilling its requirements during vegetative and reproductive periods due to rise in temperature in the month of February, resulting in lower grain as well as biological yield, which was also reported by Tewari (1990) and Rao (1986). The highest biological yield was recorded in 'UP 2338', followed by 'PBW 343' and lowest in 'WH 896' under normal sowing during 2000–2001. The high biological yield of these varieties was mainly due to their higher plant population, shoots/unit area and total dry weight/shoot, whereas high biological yield in 'UP 2425', during 2001–2002 was attributed to higher total shoot dry weight, spike dry weight and grain weight/spike. The varieties 'UP 2425' and 'WH 896' resulted in highest and lowest biological yield, respectively, under late-sown condition during both the years.

Thus delayed sowing of wheat experiences high temperature which reduced the vegetative phase and shortening of grain-growth duration forced to attain lower partitioning of dry matter and reduction in yield than timely sown crop. Varieties 'PBW 343', 'UP 2382' and 'CPAN

Table 4. Effect of sowing dates and varieties on total dry weight (g)/shoot at different stages of wheat druing 2000–2001 and 2001–2002

Treatment	Total dry weight (g/shoot) at different stages of wheat									
	35 DAS		65 DAS		Anthesis		10 DAA		Physiological maturity	
	2000–2001	2001–2002	2000–2001	2001–2002	2000–2001	2001–2002	2000–2001	2001–2002	2000–2001	2001–2002
Sowing date										
22 November	0.127	0.079	1.50	0.86	2.79	2.27	3.51	3.40	5.71	5.19
22 December	0.096	0.078	0.91	0.51	2.12	1.76	2.93	2.49	3.91	3.42
CD (P=0.05)	NS	NS	0.20	0.02	0.292	0.113	0.344	0.092	1.01	0.903
Variety										
'CPAN 3004'	0.094	0.074	1.19	0.68	2.21	2.04	3.18	2.72	4.85	4.35
'NIAW 34'	0.110	0.077	1.08	0.45	2 38	1.98	3.42	2.63	4.89	4.30
'PBW 343'	0.118	0.101	1.37	1.01	2.84	2.48	3.83	3.74	5.86	5.29
'PBW 373'	0.093	0.065	0.98	0.27	2.34	2.02	3.05	2.24	4.50	4.10
'Raj 3077'	0.104	0.075	1.31	0.64	2.50	1.71	2.95	2.73	4.38	3.83
'Raj 3765'	0.109	0.099	1.35	0.89	2.56	2.13	3.43	3.19	4.86	4.54
'UP 2003'	0.076	0.058	1.03	0.69	2.26	1.74	2.65	2.87	4.52	3.90
'UP 2338'	0.119	0.104	1.52	1.03	2.78	2.32	3.82	3.26	4.88	4.53
'UP 2382'	0.109	0.098	1.10	0.75	2.54	2.01	3.32	3.11	4.85	4.34
'UP 2425'	0.128	0.112	1.52	1.02	2.89	2.35	3.64	3.71	5.74	4.58
'WH 542'	0.070	0.047	0.96	0.29	1.98	1.55	2.63	2.29	4.17	3.88
'WH 896'	0.086	0.071	0.97	0.43	2.20	1.83	3.00	2.85	4.65	4.25
CD (P=0.05)	0.020	0.006	0.23	0.05	0.299	0.133	0.399	0.233	0.573	0.593.

DAS, Days after sowing; DAA, days after anthesis

Table 5. Effect of sowing dates and varieties on grain and biological yields of wheat

Variety	Grain yield (q/ha)						Biological yield (q/ha)					
	2000–2001			2001–2002			2000–2001			2001–2002		
	22 Nov.	22 Dec.	Mean	22 Nov.	22 Dec.	Mean	22 Nov.	22 Dec.	Mean	22 Nov.	22 Dec.	Mean
'CPAN 3004'	48.51	35.03	41.77	49.50	29.70	39.60	137.60	94.89	116.25	117.30	82.10	99.70
'NIAW 34'	43.94	33.25	38.60	47.60	28.40	38.00	127.90	91.02	109.46	113.13	71.40	91.77
'PBW 343'	59.72	37.58	48.65	53.63	33.80	43.72	148.19	109.06	128.63	124.23	84.87	104.60
'PBW 373'	44.98	29.92	37.45	47.97	29.33	38.65	123.19	93.07	108.13	120.07	67.60	93.84
'Raj 3077'	46.70	34.95	40.83	47.97	29.00	38.49	135.87	90.02	112.95	126.93	80.73	103.83
'Raj 3765'	51.67	37.75	44.71	51.77	33.13	42.45	126.45	102.18	114.32	128.33	86.93	107.63
'UP 2003'	41.41	26.94	34.18	47.30	25.87	36.59	128.99	102.77	115.88	115.93	73.13	94.53
'UP 2338'	58.32	38.01	48.17	52.63	34.87	43.75	150.73	99.28	125.01	125.60	86.23	105.92
'UP 2382'	49.58	36.13	42.86	49.67	32.07	40.87	127.90	108.34	118.12	122.80	82.80	102.80
'UP 2425'	52.00	38.96	45.49	52.43	40.37	46.40	131.17	109.06	120.12	129.70	92.47	111.09
'WH 542'	38.62	21.20	29.91	40.33	23.43	31.88	126.82	80.02	103.42	115.93	70.37	93.15
'WH 896'	40.69	21.75	31.21	43.80	25.17	34.19	120.30	68.48	94.39	115.93	84.87	100.40
Mean	48.01	32.62		48.70	30.40		132.29	96.13		121.41	80.46	
CD (P=0.05)												
Dates (D)		4.32			1.79			8.12			2.75	
Varieties (V)		4.10			3.28			7.44			6.71	
Comparing 2 varieties at same date of sowing		5.79			4.63			10.53			9.49	
Comparing 2 dates at same or different varieties		6.69			4.69			30.99			9.39	

3004' with higher biomass accumulation along with longer vegetative and reproductive period were found to be more suited to timely sowing, whereas, 'UP 2425' and 'Raj 3765' with short duration were found to be more suited to late-sown conditions as the duration from anthesis to maturity was less altered due to higher temperature during maturation phase.

REFERENCES

Ahuja, K.N., Lal, R.B., Ashok Kumar and Kumar, A. 1996. Effect of seed rate, date and method of sowing on growth and yield of wheat. *Annals of Agricultural Research* **17** : 190–192.

Asana, R.D. 1966. Physiological analysis of yield of wheat in relation to water stress and temperature. *Journal of Post-graduate School* **4** : 17–31.

Mc Donald, G.K., Sutton, B.G. and Ellison, F.W. 1983. The effect of time of sowing on the grain yield of irrigated wheat in Namoi valley. *Australian Journal of Agricultural Research* **34** : 229–240.

Rao, Y.H. 1986. 'Influence of sowing dates on growth, grain development and yield of wheat genotypes'. Ph.D.Thesis (Agriculture), Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, Uttaranchal.

Sanwal, Kanchan. 1993. 'Post-anthesis assimilate distribution and yield of wheat varieties under different sowing dates.' M.Sc Thesis (Agriculture), Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, Uttaranchal.

Sanwal, Kanchan, 1998. Studies on heat tolerance in wheat genotypes. Ph.D. Thesis (Agriculture), Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, Uttaranchal.

Singh, Dharam Pal. 1988. Studies on photosynthesis, growth, development and yield of wheat genotypes under different sowing dates. M.Sc.Thesis (Agriculture), Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, Uttaranchal.